Interim Conceptual Site Model

January 29, 2014

Document Structure

- Main Body
  1. CSM Overview and Components
  2. River Characteristics and Setting
  3. Environmental Conditions
  4. Risk Receptors and Pathways
  5. Fate and Transport
  6. Summary

- Appendices

  A – Evaluation of the Low Resolution Coring Data

  B – Overview of the LPR Historical 2,3,7,8-TCDD Source and the Support for Its Regional Dominance

CSM Overview

- Describes current understanding of physical, chemical and biological processes controlling fate and transport in the system
- Uses data from past studies and extensive data collected as part of RI/FS process
  - Bathymetric surveys
  - Physical, chemical and radiological sediment data
  - Physical and chemical water column monitoring (CWCM)
  - Benthic and fish tissue analysis
- CSM is being refined to reflect new/additional information received since the document was prepared

River Characteristics and Setting

- Three major classifications
  - Freshwater River Section
  - Transitional River Section
  - Brackish River Section
- Particle size transitions from coarse to silt/fine grained upstream to downstream

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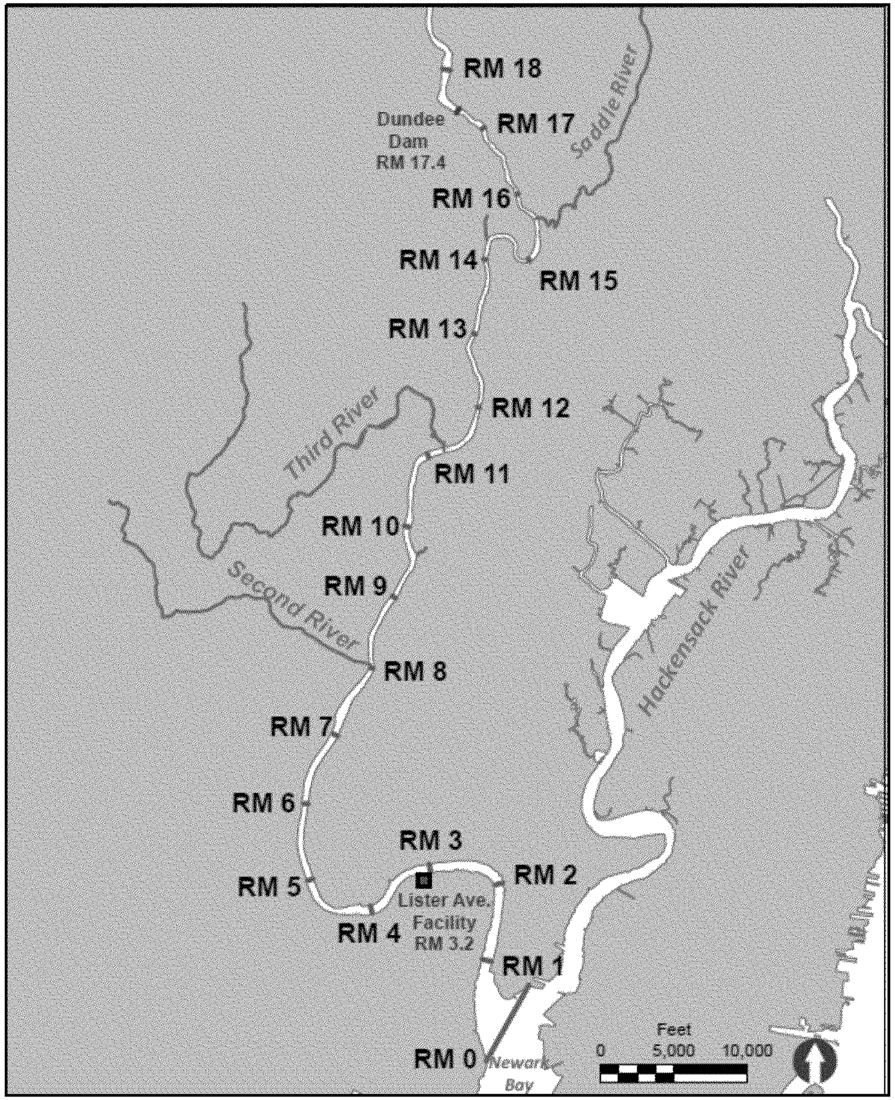


River Characteristics and Setting

- Heavy urbanization and industrialization has
  - Resulted in a broad range of contaminant loadings from a multitude of sources
  - Severely degraded habitats and adversely impacted the benthic community
  - Brought about altered shoreline and several bridge and utility crossings
  - Introduced non-chemical stressors to the ecosystem
- Distinguished from other urban sites by atypical levels of 2,3,7,8-TCDD in sediments

Contaminants

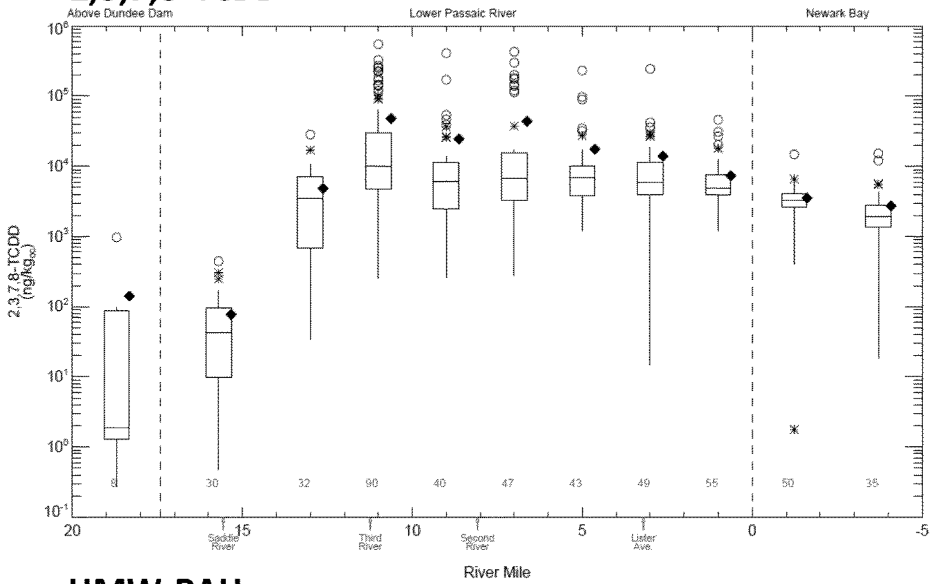
- Contaminants examined include
  - 2,3,7,8-TCDD
  - PCBs
  - HMW and LMW PAHs
  - DDx, Dieldrin, Chlordane
  - Mercury, Copper, Lead

Sediment Data Treatment

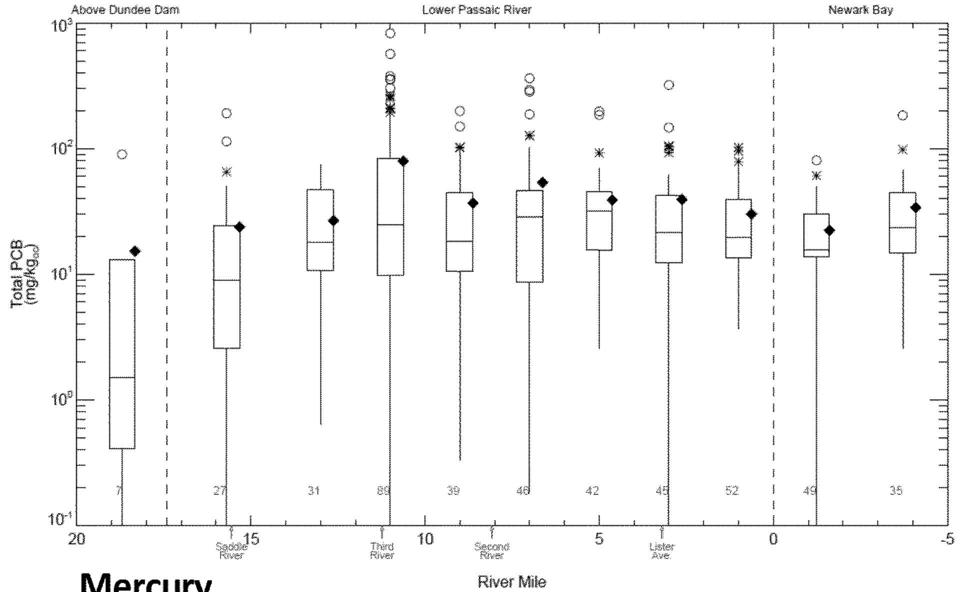
- Sediment data OC-normalized to reflect hydrophobic nature of contaminants and differences in sediment TOC
- Data grouped spatially before plotting
  - 2-mile bins within lower 14 miles of LPR
  - RM 17.4 to RM 14 and RM 20 to RM 17.4 treated as single bins
  - Newark Bay divided equally – RM 0 to RM -2.475 and RM -2.475 to RM -4.95
- Only post-2000 data used
  - Provide complete spatial coverage throughout LPR
  - Consistent set of objectives and protocols

Surface Sediment Concentrations

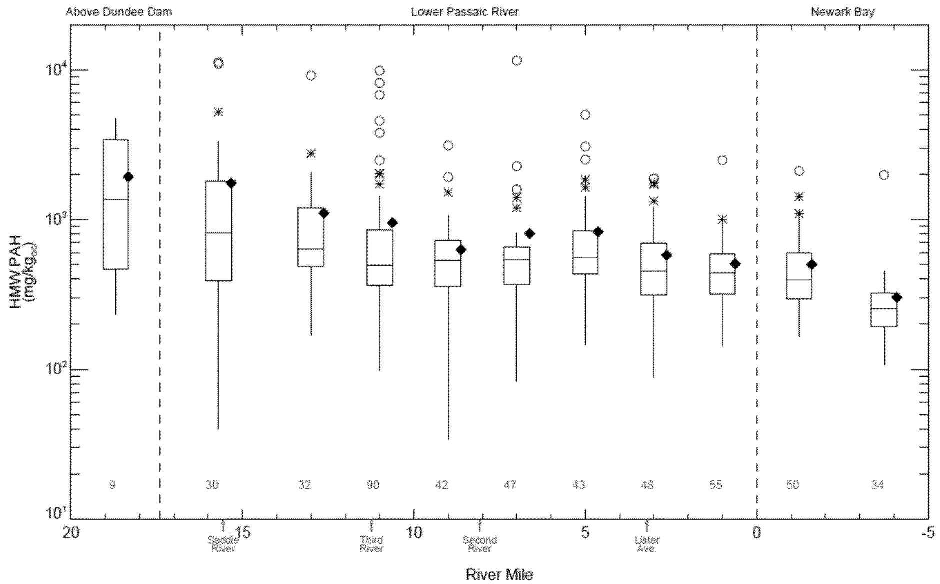
2,3,7,8-TCDD



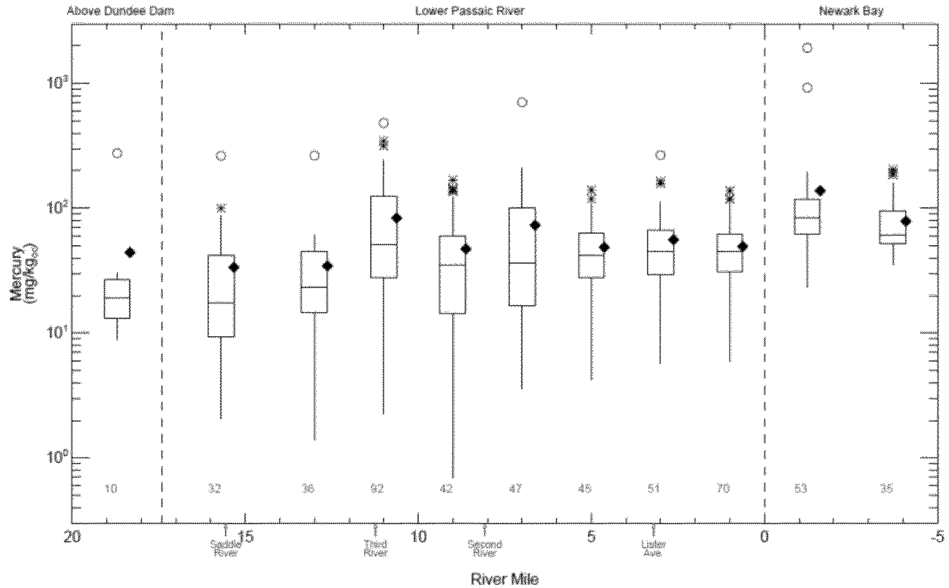
Total PCBs



HMW PAHs



Mercury



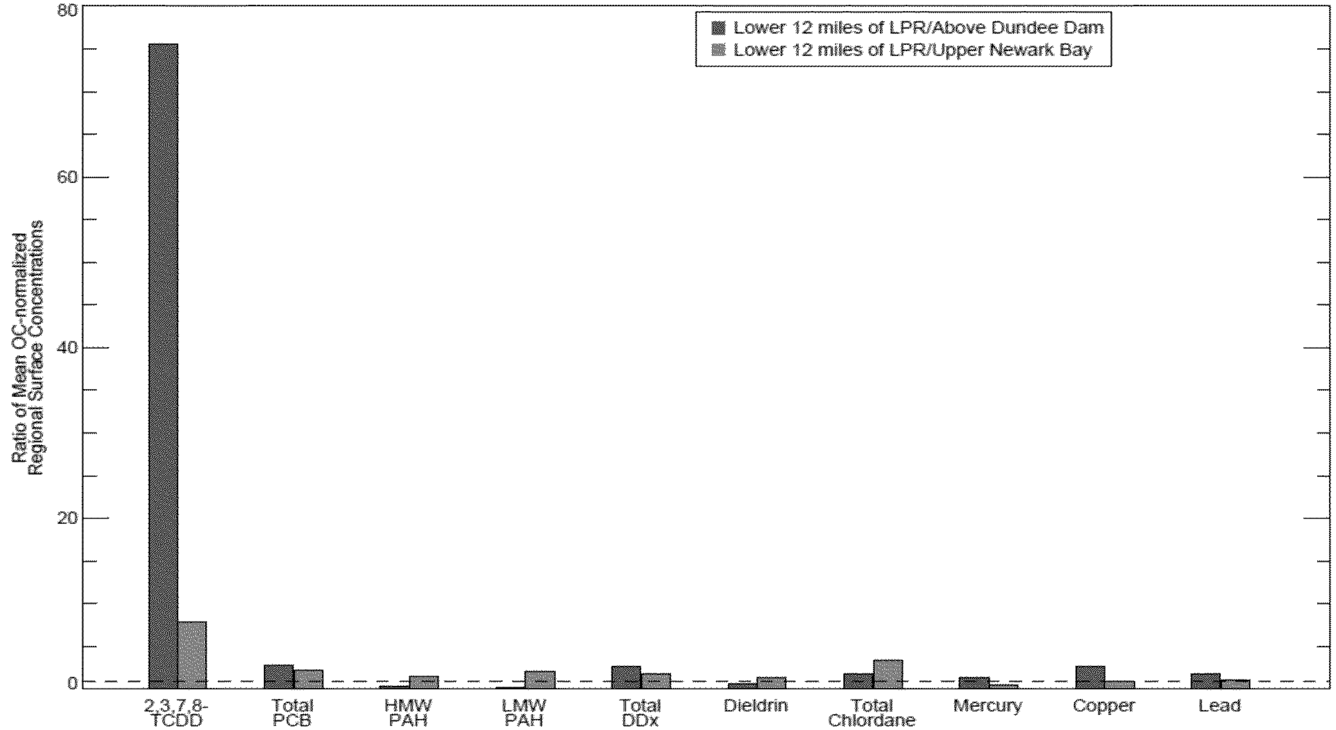
Surface Contaminant Concentrations

- Surface contaminant concentrations in lower 12 miles are well correlated with surface 2,3,7,8-TCDD concentrations
- Within lower 12 miles, concentrations exhibit no particular large scale trends
- Outside of lower 12 miles, trends differ from 2,3,7,8-TCDD
- Indicates influence of upstream, downstream, and/or watershed sources for different contaminants

Water Column and Tissue Trends

- Water column concentrations well correlated to TSS concentrations
- Mean water column concentration
  - Trends similar to those of surface sediments
  - Generally lower than surface sediment concentrations
- Tissue concentration trends also similar to surface sediment concentration trends
- Analyses are ongoing

External Sources



- Average surface sediment 2,3,7,8-TCDD concentration in Lower LPR is substantially higher than those in Upper Passaic River and Upper Newark Bay
- Other contaminants are generally within factor of 2 to 5 of those in the Upper Passaic River and Upper Newark Bay

External Sources

- One or more tributaries can contribute to elevated contaminant levels at least locally for many contaminants
- Insufficient information to understand the relative importance of other potential ongoing sources (i.e., CSOs, direct discharges, etc.)

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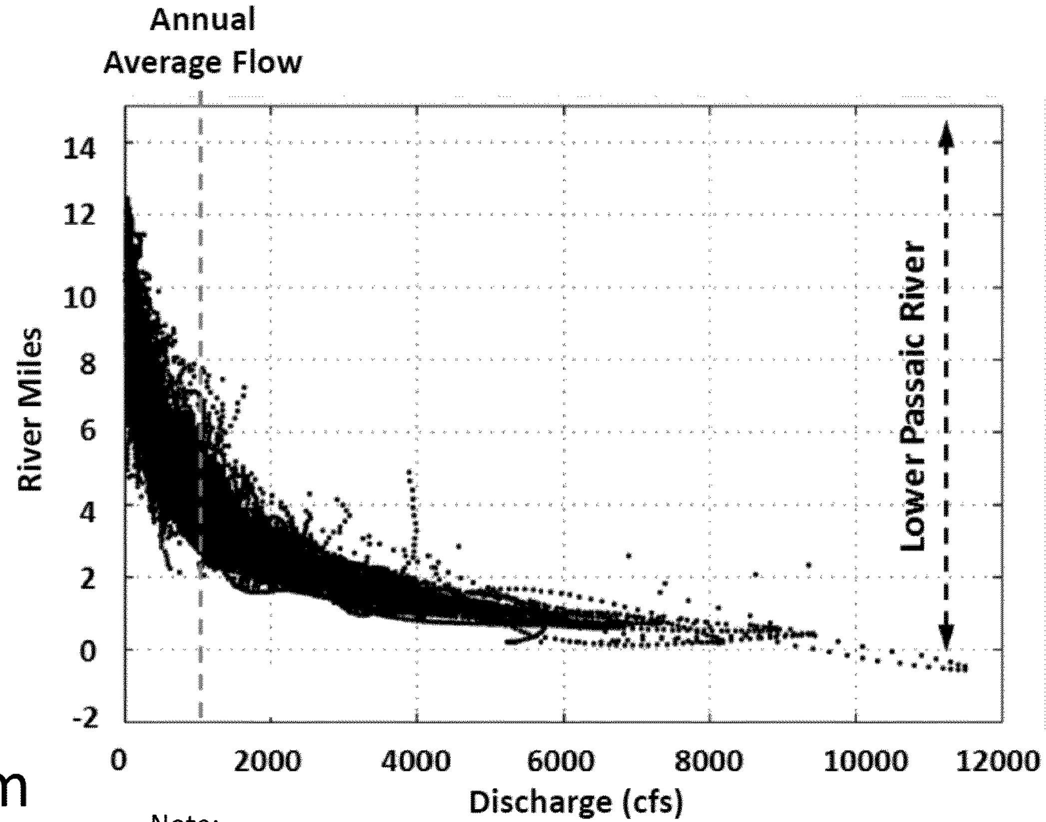
Fate and Transport

- Major fate and transport mechanisms
  - Estuarine processes
  - Sediments
    - Scour and deposition
    - Sedimentation
    - Sediment stability
- Contaminants
- Natural Recovery

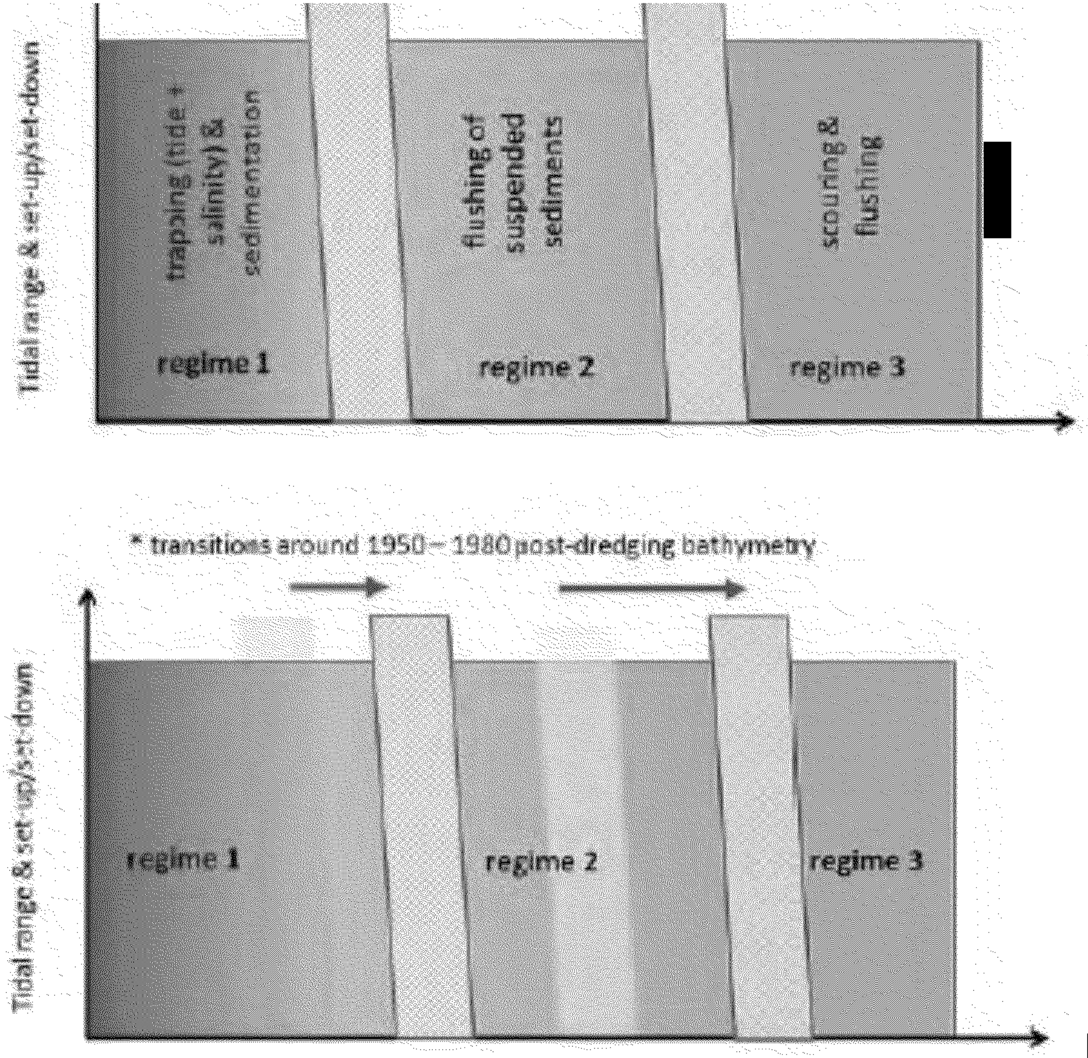
Estuarine Processes

- LPR hydrodynamics a function of
  - River flow
  - Tides
  - Salinity gradients
  - Offshore setup/setdown events
- Estuarine circulation
  - Upriver flow in the bottom portion of the water column
  - Downriver flow in the upper water column
- Location of salt front varies



Note:
Computed salinity intrusion (salt front at 2 ppt, bottom) as a function of river discharge, based on a 10-yr hydrodynamic model simulation (results filtered to remove tidal variability)

Scour and Deposition



- Transition between regimes a function of river flow
  - Low flows – tidal asymmetry and gravitational circulation dominate, infilling
  - High flows – scour and downstream transport
- Transition has shifted over time

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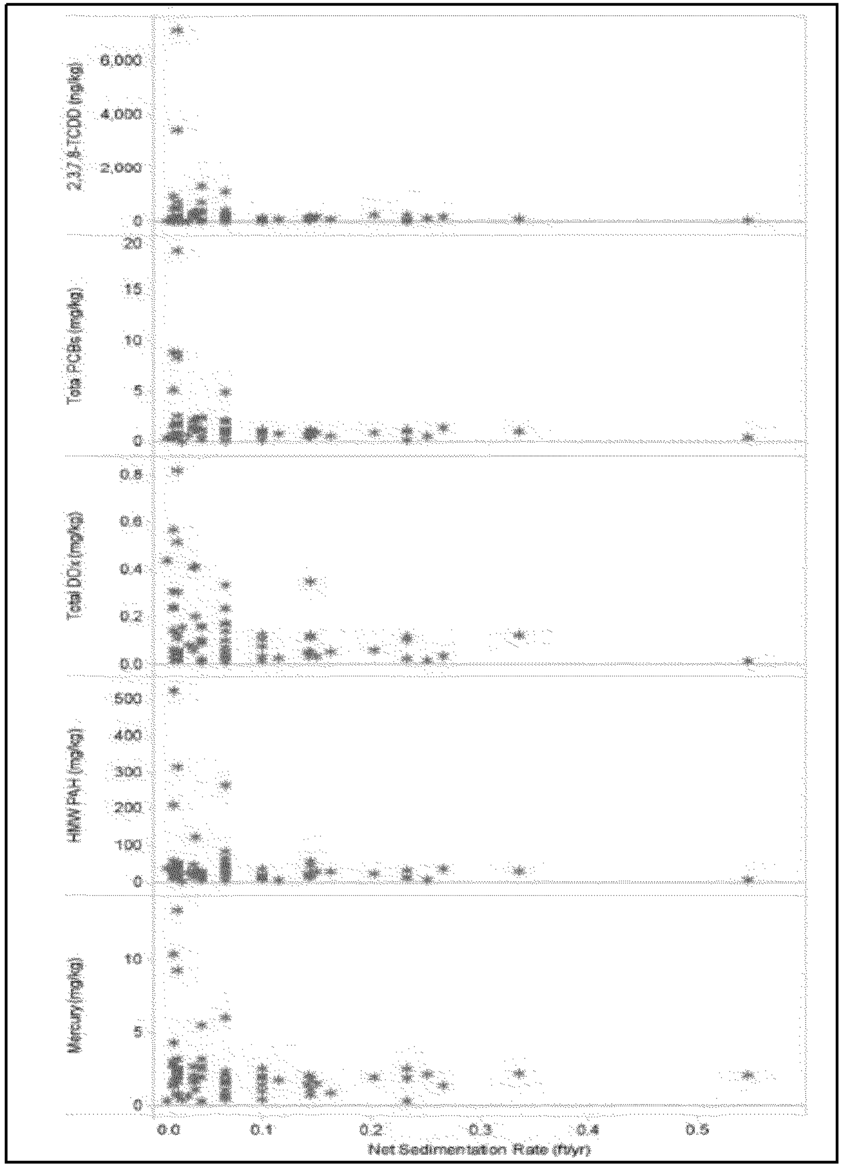
Sedimentation



- High surface concentrations at locations with low sedimentation rates
- Higher sedimentation rates in lower 7 miles and within navigation channel
  - Greater rates when channel was maintained
- Low sedimentation rates in point bars and mudflats
- Most cores between RM 1 and RM 7 show a Cs-137 peak at depth
  - Suggests a stable sediment bed

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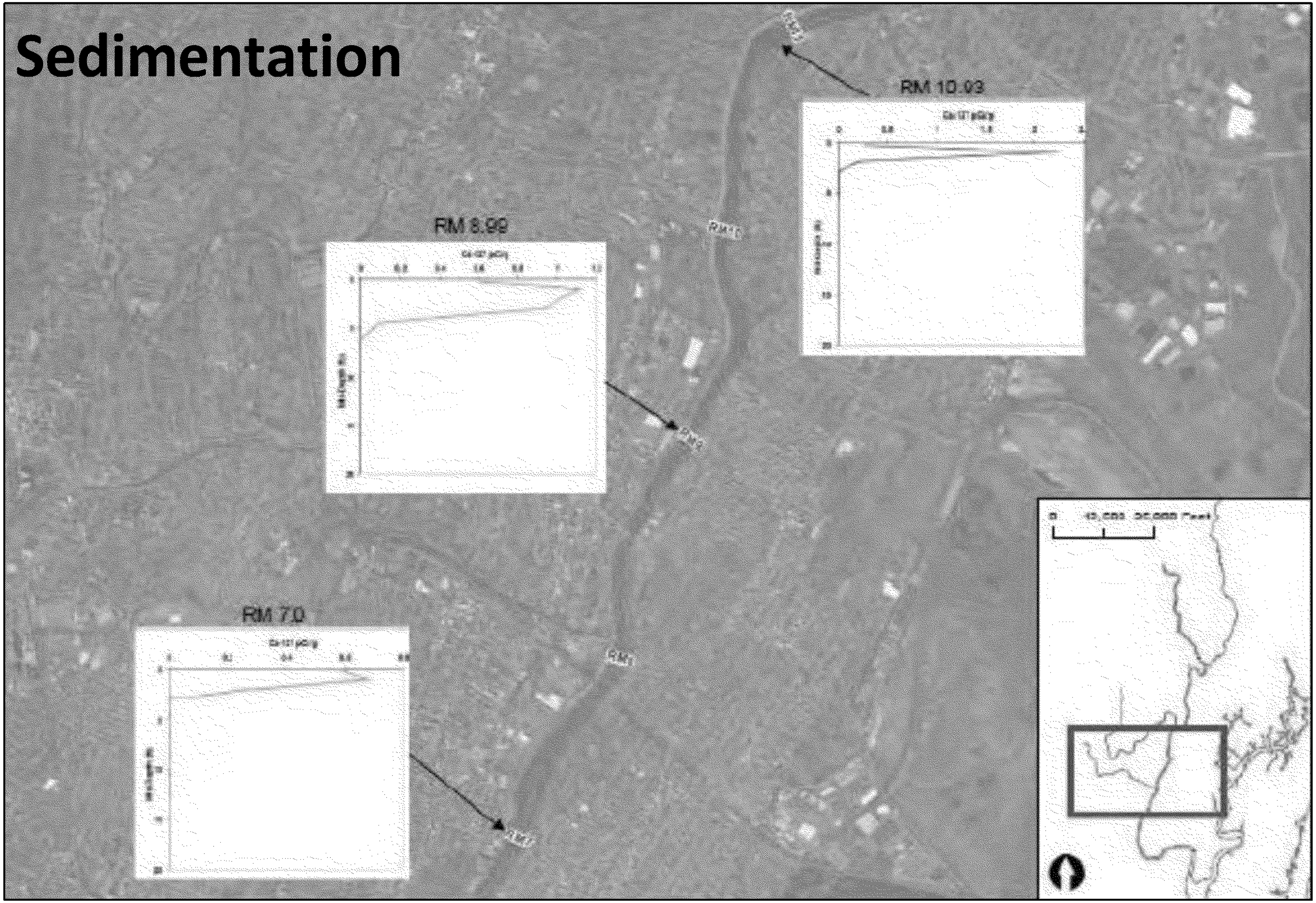
Sedimentation



Bathymetry

- Large set of bathymetric data (historical and recent)
- Between 1949 and 2010 – the navigation channel from RM 2 to RM 7 was largely net depositional
- Some of these depositional areas were net erosional between 1995 and 2010
  - Result of frequent post-1995 high flow events
- Large areas with no change in recent surveys
- Limited shallow erosion due to Hurricane Irene
- Areas with cyclic erosion/deposition patterns

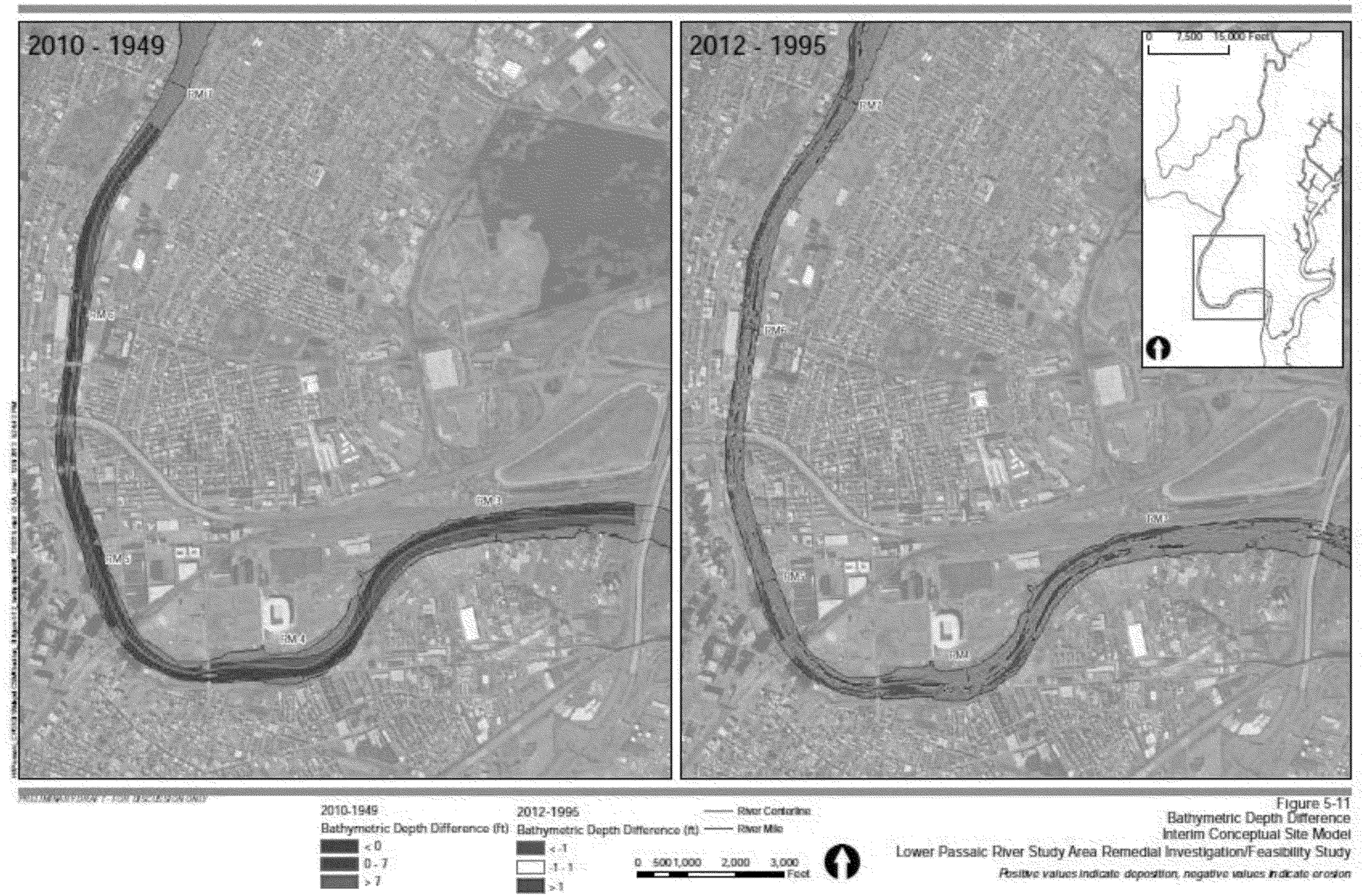
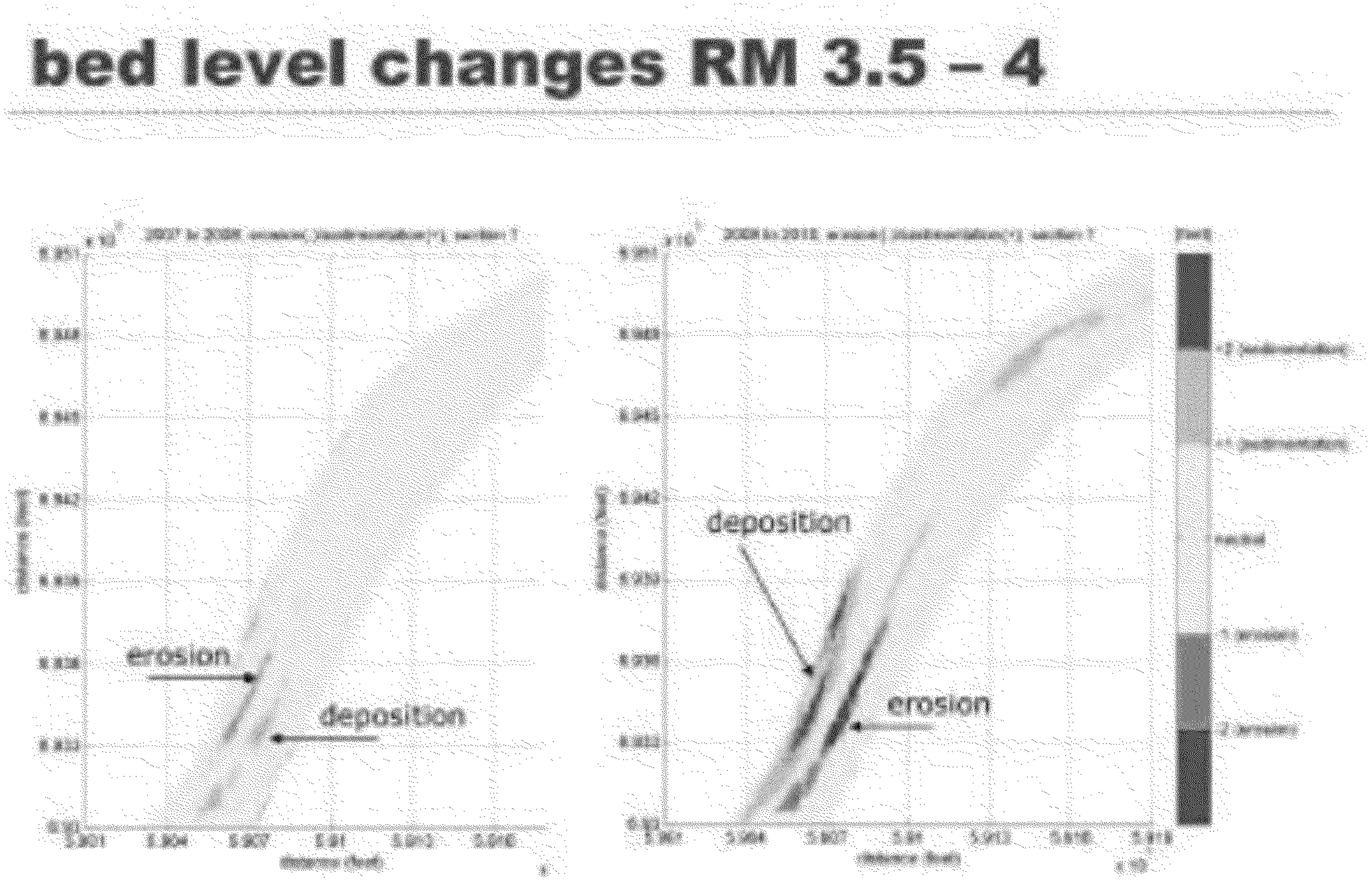


Figure 5-11
Bathymetric Depth Difference
Interim Conceptual Site Model
Lower Passaic River Study Area Remedial Investigation/Feasibility Study
Positive values indicate deposition, negative values indicate erosion

Bathymetry – Cyclic Erosion and Deposition



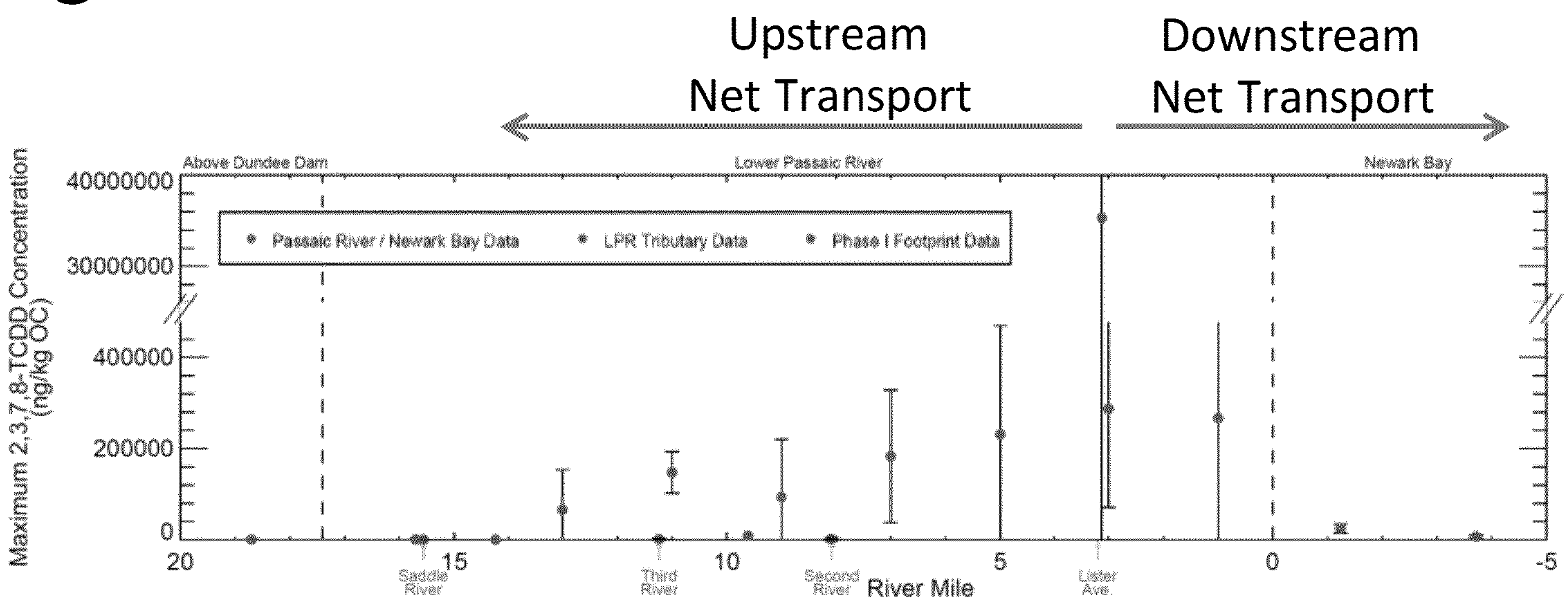
Contaminant Fate and Transport

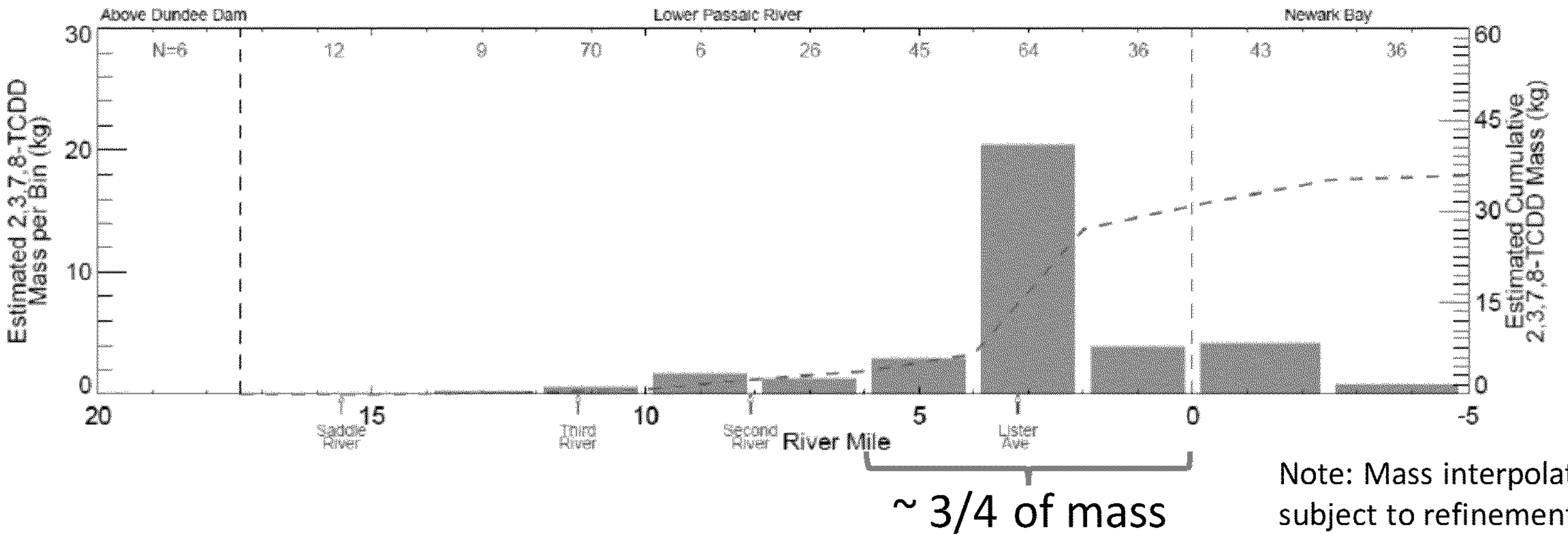
- Major processes affecting sediments also affect LPR COPCs
  - Estuarine/tidal processes
    - Tidal currents □ resuspension and deposition
    - Estuarine circulation
  - Event-driven scour
  - Deposition/burial
  - Sediment bed processes
- Additional COPC-specific considerations
  - Distribution in sediments (horizontal, vertical)
  - Boundary loadings
  - Sorption, diffusion, and other F&T processes

Contaminant Fate and Transport

- Focus on 2,3,7,8-TCDD to infer transport dynamics of LPR contaminants
  - Dominant historical source □ Lister Ave discharge
- Observations grouped as follows
  1. Long-term Transport □ Sediment bed trends reflect time-integration of transport processes
  2. Short-term Transport □ Water column trends show bed-water column interactions

Contaminant Fate and Transport
Long-Term Trends from Sediment Data





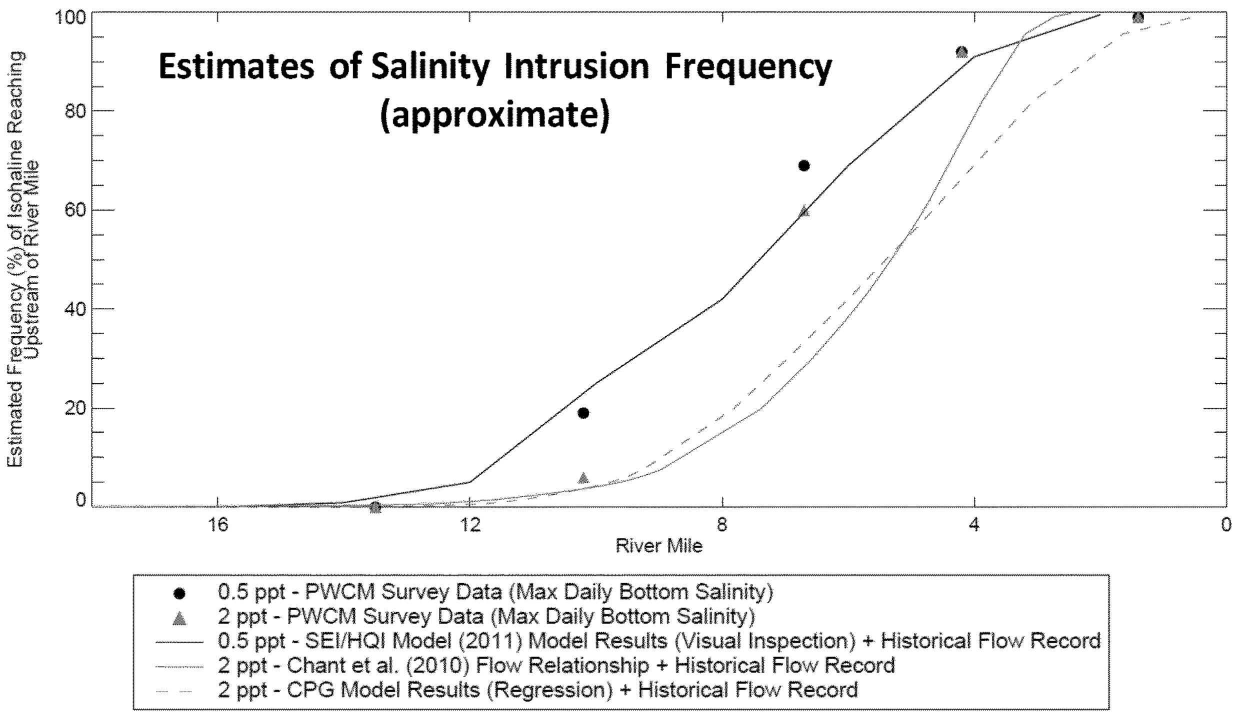
Note: Mass interpolation subject to refinement

Contaminant Fate and Transport Long-Term Trends from Sediment Data

- LPR was historically an effective contaminant trap
  - About 3/4 of estimated mass in the lower 6 miles
- Net upstream transport to approx. RM 14, reflecting
  - Declining upstream transport potential (estuarine processes)
  - Declining long-term trapping potential (narrower cross-section, less fine sediment deposits)
- Net downstream transport into Newark Bay
  - Declining influence of LPR solids with distance, consistent with settling and mixing with other solids

Contaminant Fate and Transport
Long-Term Trends – Upstream Transport

- Upstream transport potential is consistent with salinity intrusion considerations
  - Expected to have been higher in the past
    - Deeper channel
    - Drought in the early-to-mid 1960s



Contaminant Fate and Transport
Short-Term Trends from Water Column Data

- Water column contaminant concentrations in the LPR exhibit a wide range, spanning orders of magnitude
- Concentrations are well correlated with suspended solids
  - Consistent with particulate phase dominance

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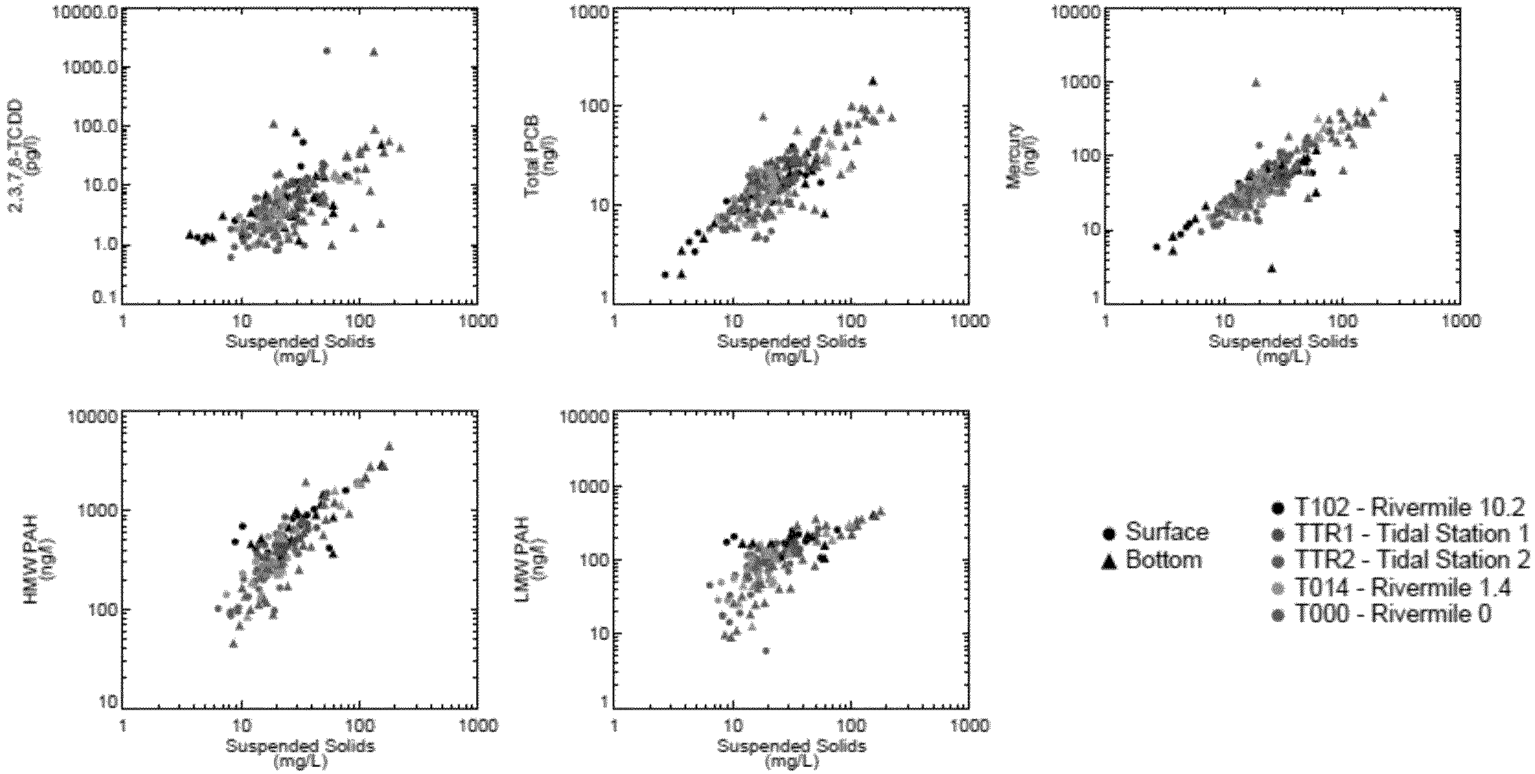

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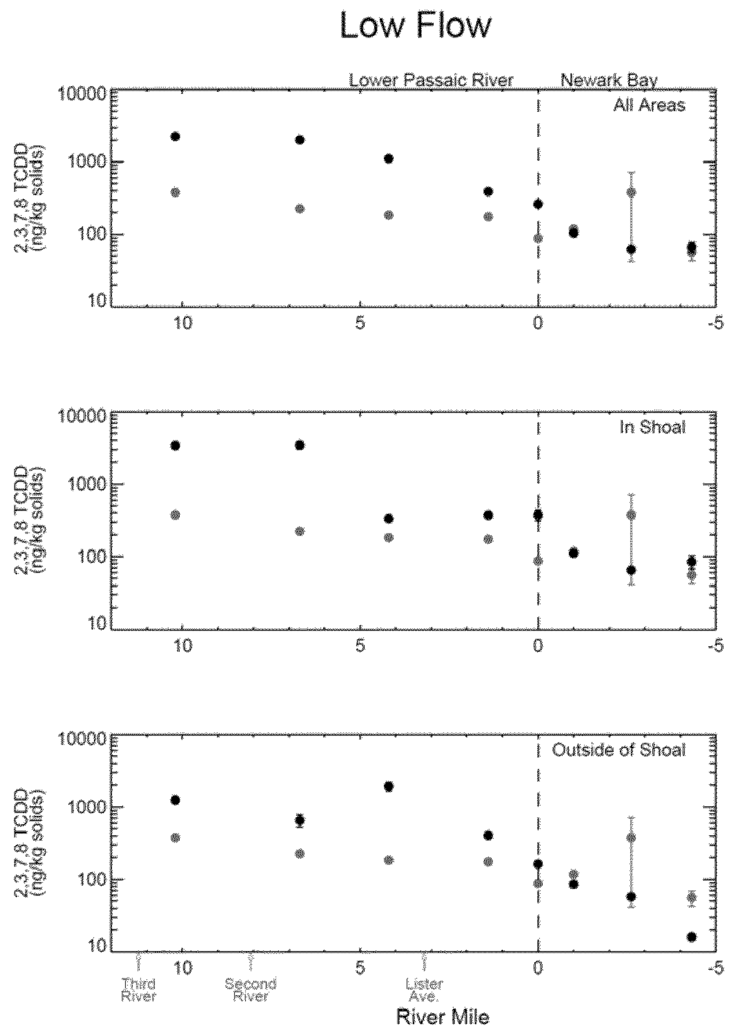
Contaminant Fate and Transport
Short-Term Trends – Water Column Fluxes

- On average, solids normalized water column 2,3,7,8-TCDD concentration are lower than the 0-6 inch concentration of the bed
- Conceptual model: Vertical bed concentration gradients reduce flux to water column
  - Near-surface gradient within the parent bed
  - Gradient between the parent bed and overlying un-consolidated “fluff” layer
  - Under investigation as part of CFT model development



Natural Recovery
Conceptual Model for Sediment Recovery

- Deposition
  - Introduces particles typically having lower concentrations
  - Down-mixing dilutes the concentrations in the surface sediment layer
- Net Sedimentation
  - Buries higher concentrations
- Resuspension and diffusion
  - Move contaminants out of the sediments
  - Redistributes contaminants

Natural Recovery Patterns for 2,3,7,8-TCDD

- It has been widespread
  - Highest concentrations deposited in the 1950-1960s are typically buried
- It correlates with the rate of net sedimentation
  - Cores with the highest sedimentation rates tend to have relatively low surface sediment concentrations
- It has varied spatially
  - Greater in the lower 6 miles of the river
  - Some shoal deposits (e.g., RM 7.5; RM 10.9) show little evidence of recovery

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Natural Recovery
Contemporary Rate – 2,3,7,8 TCDD

- Estimated by comparing RM 1 to 6.8 surface sediment concentrations in the mid-1990s and in the late-2000s
- Gross comparisons of all-data averages show no decline
  - Value of this comparison is compromised by spatial biases between the data sets
- Attempted to overcome the spatial biases by mapping concentrations over the full river bottom
  - Partitioned the river bottom for purposes of mapping
    - Shoals
    - Non-depositional regions of the channel
    - Historically depositional regions of the channel that have experienced erosion back to within 6 inches of the 1966 surface
    - Historically depositional regions of the channel that have maintained more than 6 inches of sediment above the 1966 surface

Natural Recovery
Contemporary Rate – 2,3,7,8 TCDD

- Little change in overall averages, but a spatially variable recovery
- Areas predicted by CPG ST model as
  - Erosional □ show an increase in concentration
  - Depositional at < 1 cm/yr □ show little change
  - Depositional at > 1 cm/yr □ show 30 – 35% recovery
    - Roughly matches the drop in aquatic biota concentrations

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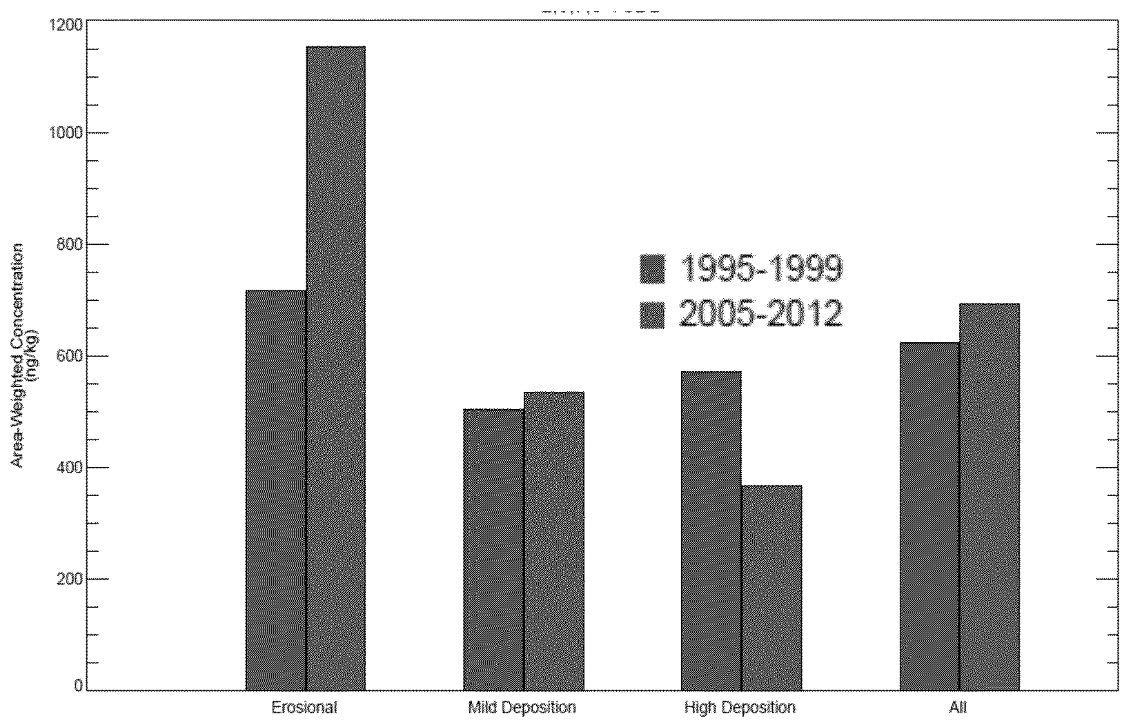

Note: Ongoing refinements to mapping may alter the assessment of rate

Natural Recovery
Future Recovery

- Natural recovery may slow in the future
  - Depends on concentration difference between depositing particles and surface sediments
    - Concentration difference declines over time with recovery
      - For several contaminants, at or near regional background
    - The importance of non-recovering areas within the LPR may be increasing, to the extent that they control concentrations on particles depositing in the recovering areas
  - Also depends on sedimentation rates
    - Net sedimentation rates are likely declining, although should on average be maintained at rate of sea level rise

Human Health Risk Assessment

- Primary potential human health receptors are recreational users (anglers, boaters, and waders) and workers
- Key human health exposure pathways include
  - Direct contact/uptake from nearshore mudflat sediment
  - Direct contact/uptake from surface water
  - Consumption of fish and/or crab
- Inhalation of outdoor air minor pathway

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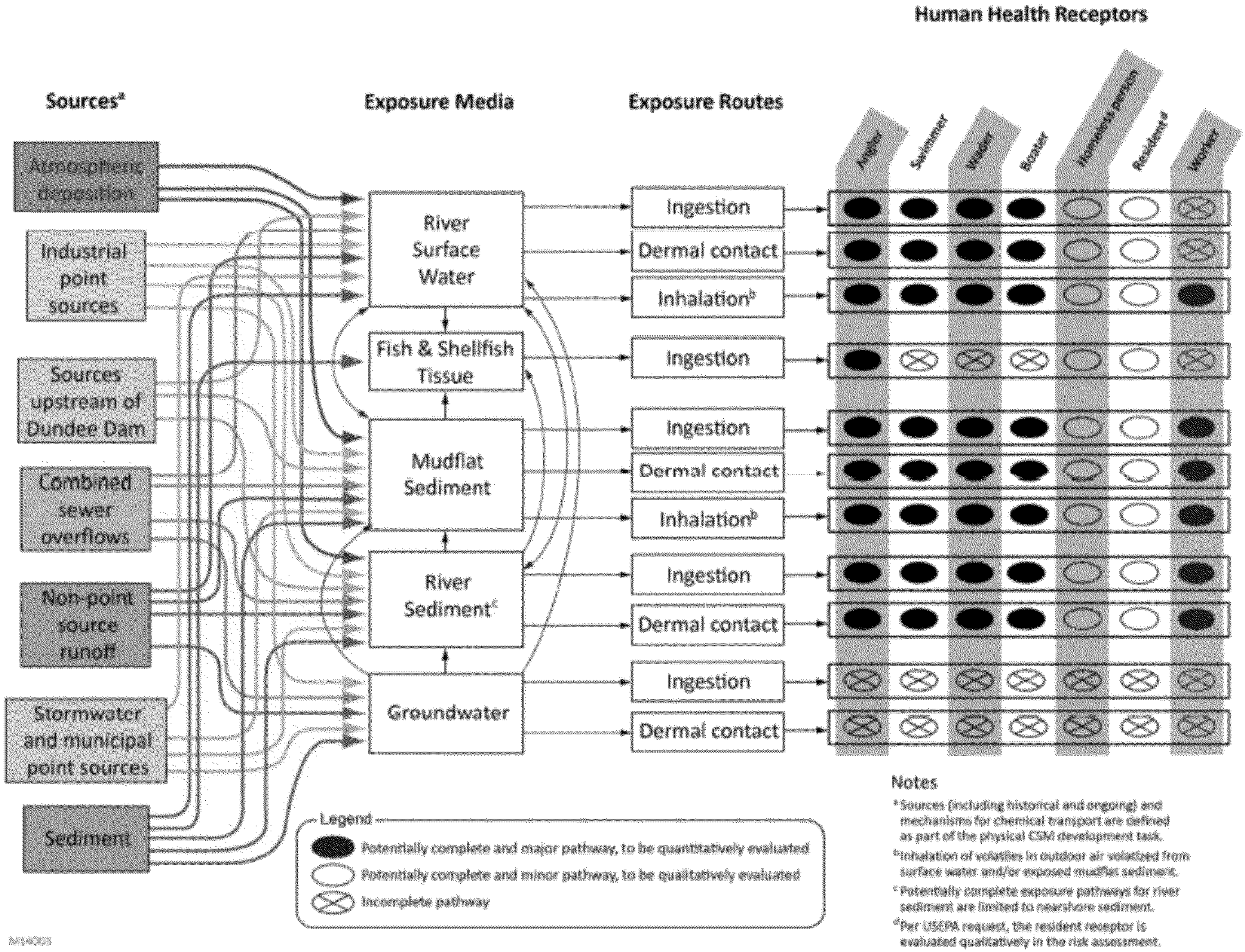
General Human Health CSM for the LPRSA



Preliminary CSM – For Discussion Purposes Only

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Key Exposure Scenarios and Risks

- Preliminary risk evaluations indicate that fish and crab consumption are the risk-driving exposure pathways
  - Both cancer and noncancer risks above targets
  - Fish diet that includes carp drives consumption risk
- Direct contact with accessible surface sediment along east bank in vicinity of RM 6-7 also significant

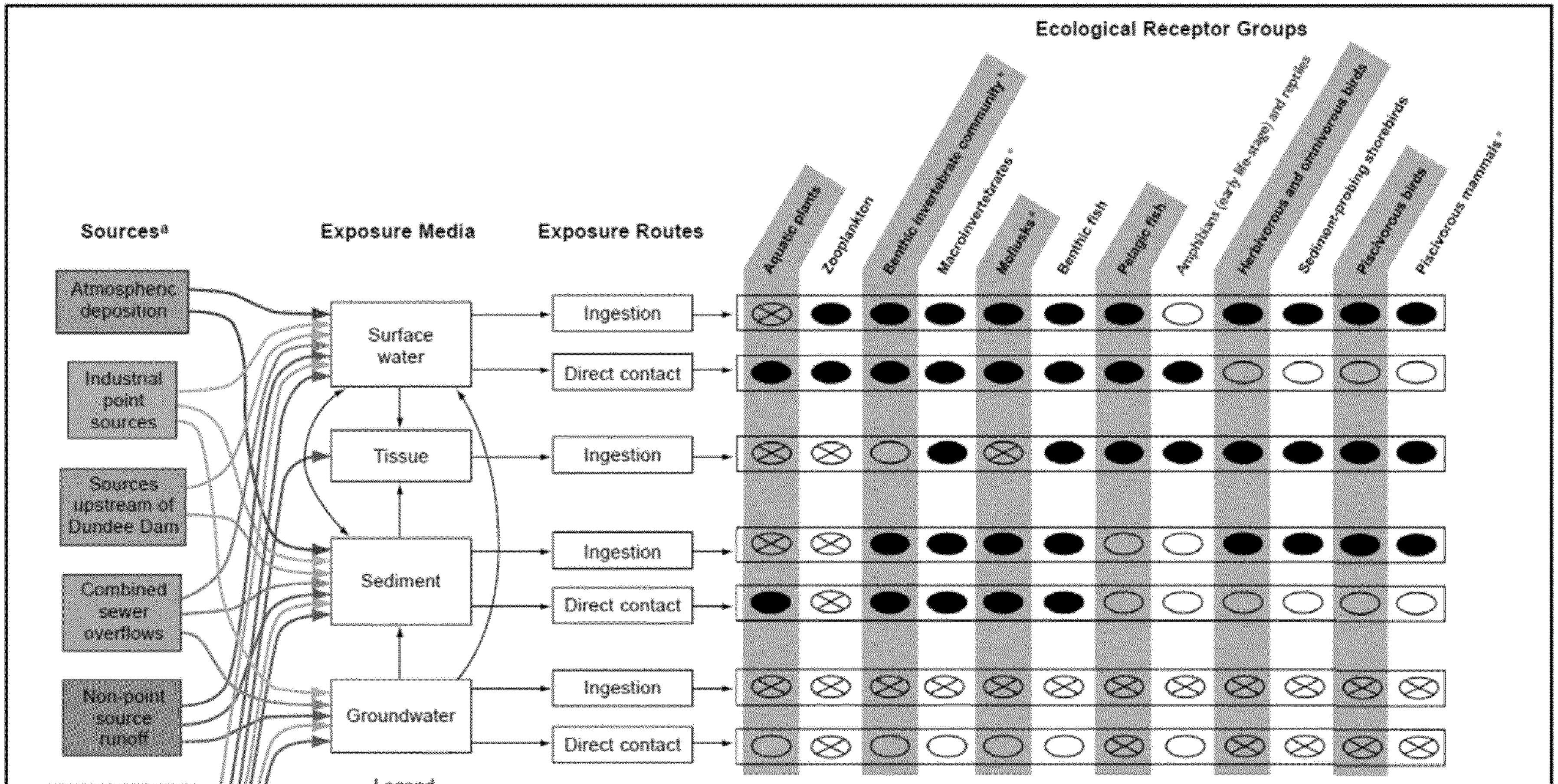
Risk Drivers

- Preliminary data evaluations suggest that 2,3,7,8-TCDD is the major human health risk driver
- Other bioaccumulative compounds, including PCBs, pesticides, and mercury, also contribute to human health risks
- Urban background conditions contribute to cumulative risk burden
  - Levels of PCBs, organochlorine pesticides, and mercury elevated in fish tissue above dam

Ecological Risk Receptors and Pathways

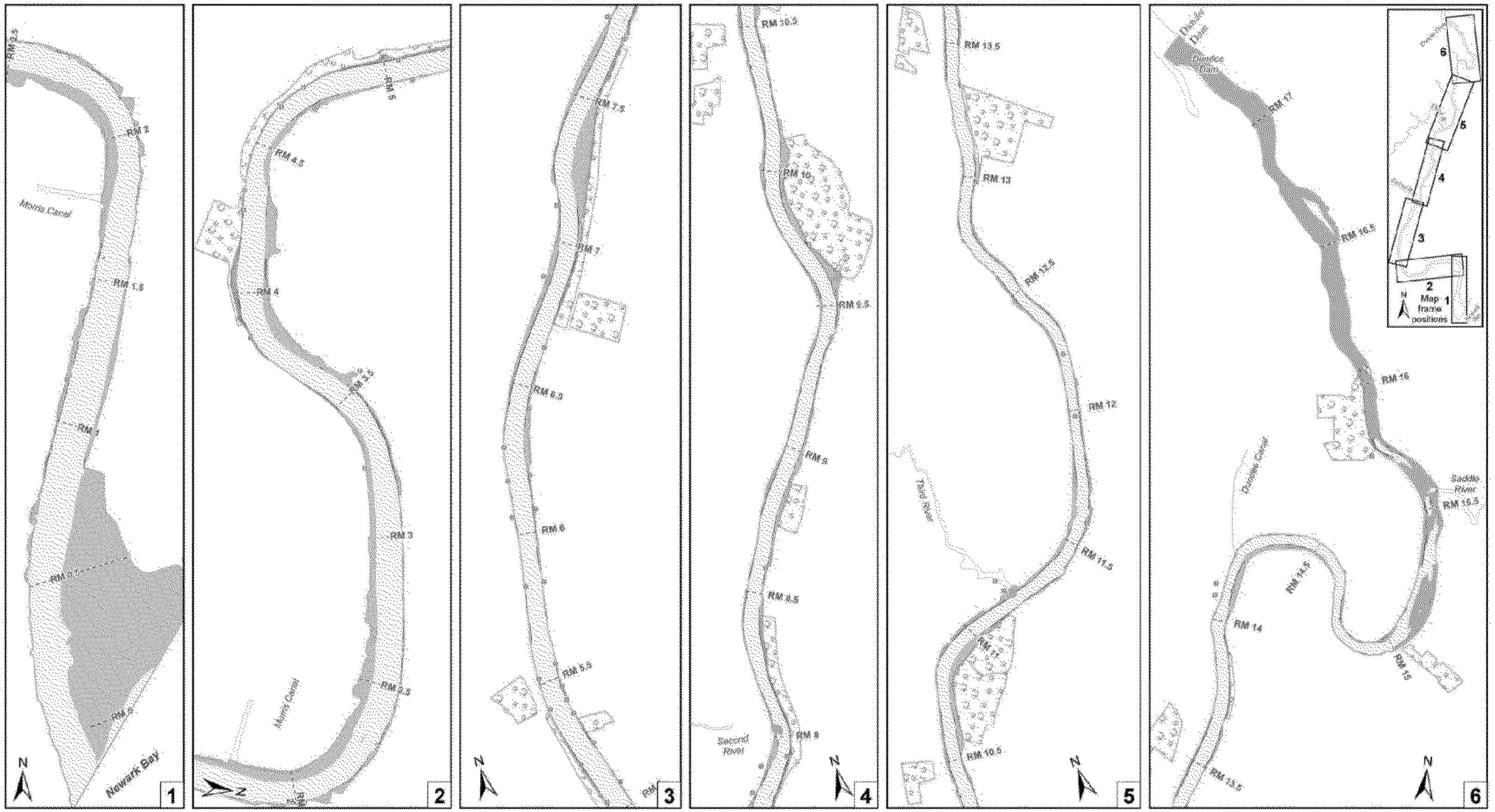
- General ecological CSM for the LPRSA
- Benthic community
- Other stressors

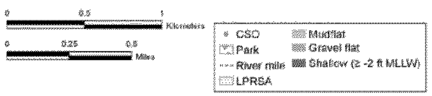
General Ecological CSM for the LPRSA



Notes:
a Sources (including historical and ongoing) and mechanisms for chemical transport will be defined as part of the physical CSM development task.
b Benthic invertebrate community is represented by infauna.
c Macroinvertebrate receptors are represented by blue crab in the estuarine zone and crayfish in the freshwater zone.
d Mollusk receptors are represented by bivalves.
e Piscivorous mammals are expected to be protective of omnivorous and herbivorous mammals. Therefore, no receptors were selected for those feeding guilds.

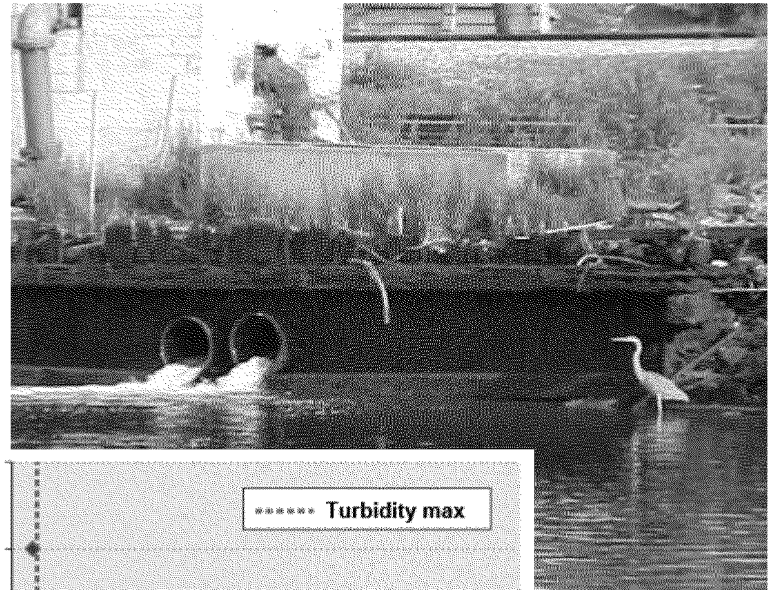
Shallow Nearshore Areas Provide Preferential Feeding Habitat

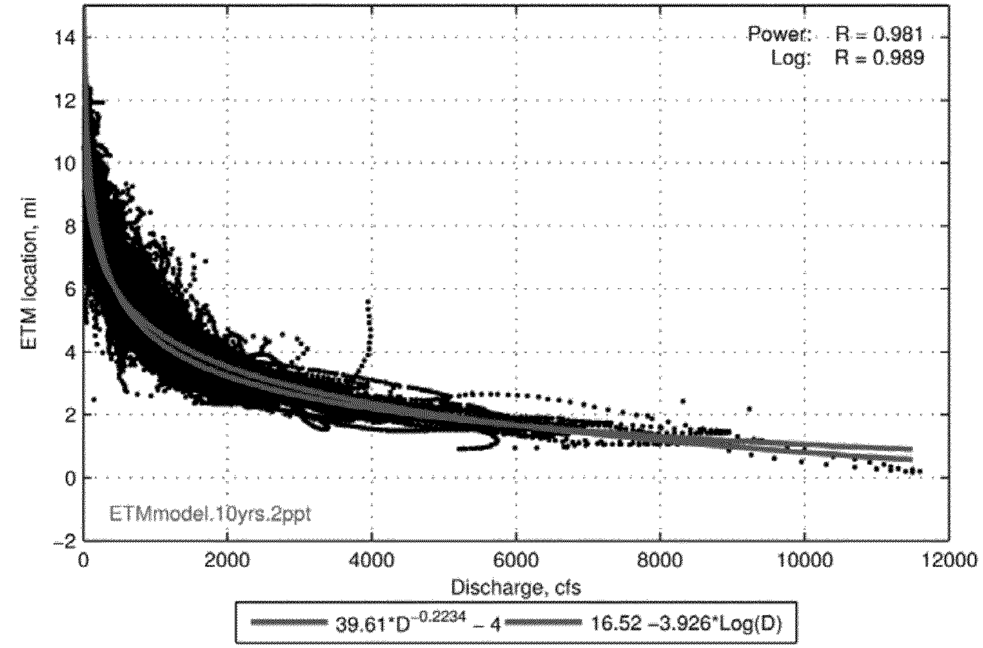


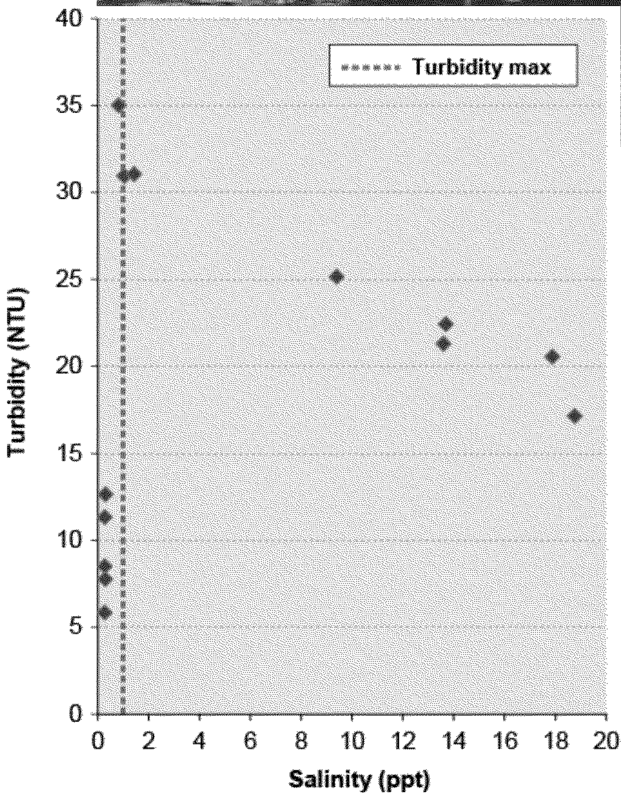


Note:
Shallow flat areas for ecological receptors are those areas where the river bottom slope is ≤ 6° and the depth is ≥ -4.5 ft NGVD29 (i.e., -2 ft MLLW), based on the 2007 bathymetric survey conducted by Gahagan & Bryant Associates, Inc. (GBA). Areas of the LPRSA not covered by the GBA survey (i.e., southeast Kearney Point, PM 16.5 to RM 17.4, and some nearshore shallows) have been extrapolated either from contours derived from the GBA baythmetry data, or from NOAA data (specifically Kearney Point). Mudflats are defined as areas with silt and/or sand river bottom. Gravel flats consist of coarser material. Surface texture was delineated by Aqua Survey, Inc. in its 2005 Geophysical Survey. All of Kearney Point is assumed to be sand or silt based on field experience.

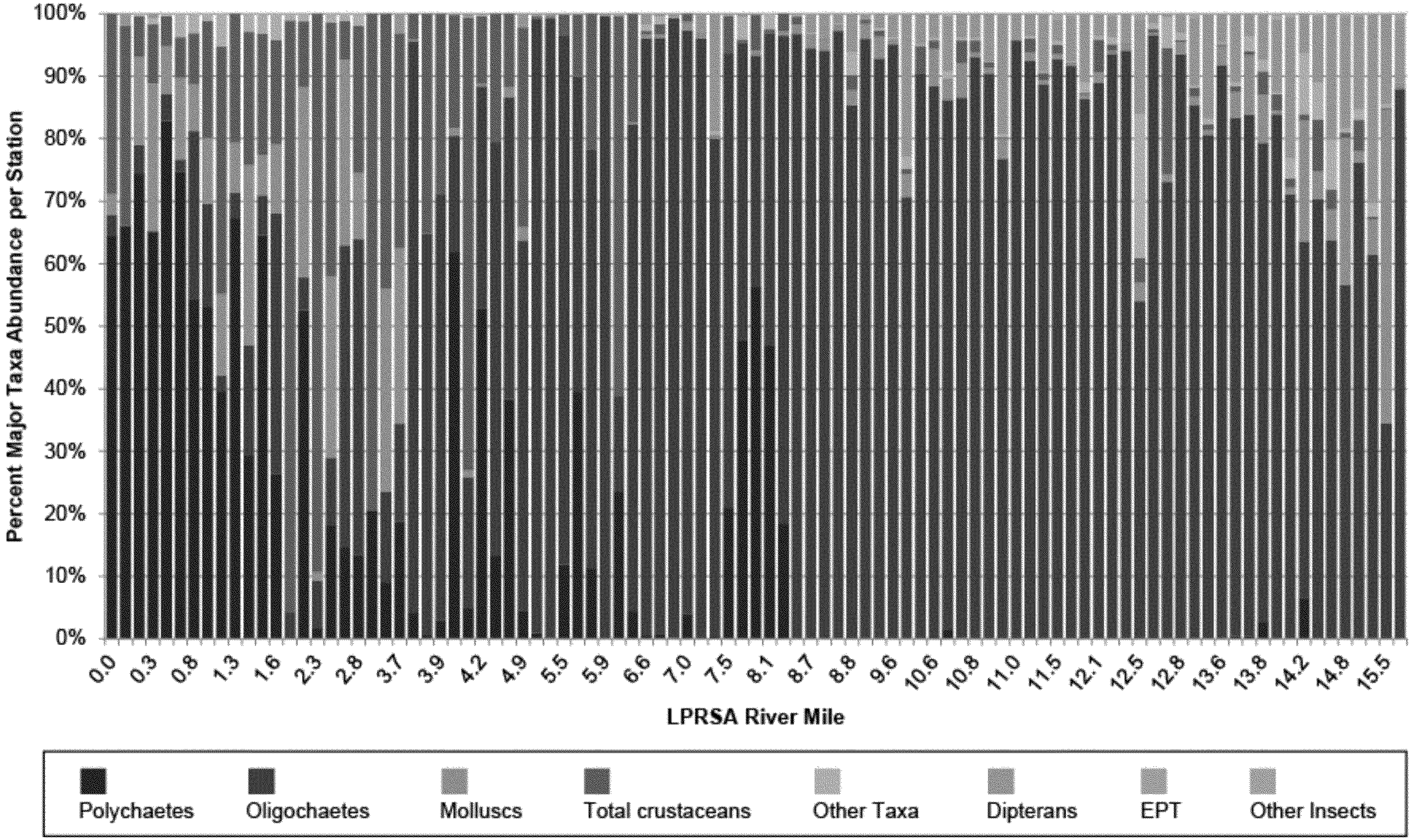
LPRSA an Urbanized Salt Wedge Estuary





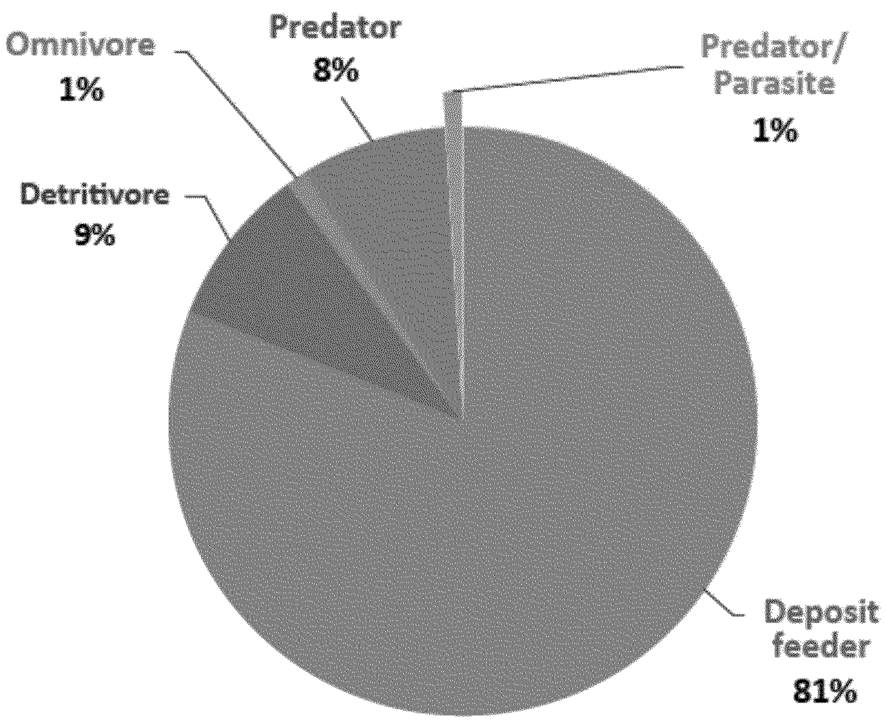


Benthic Community

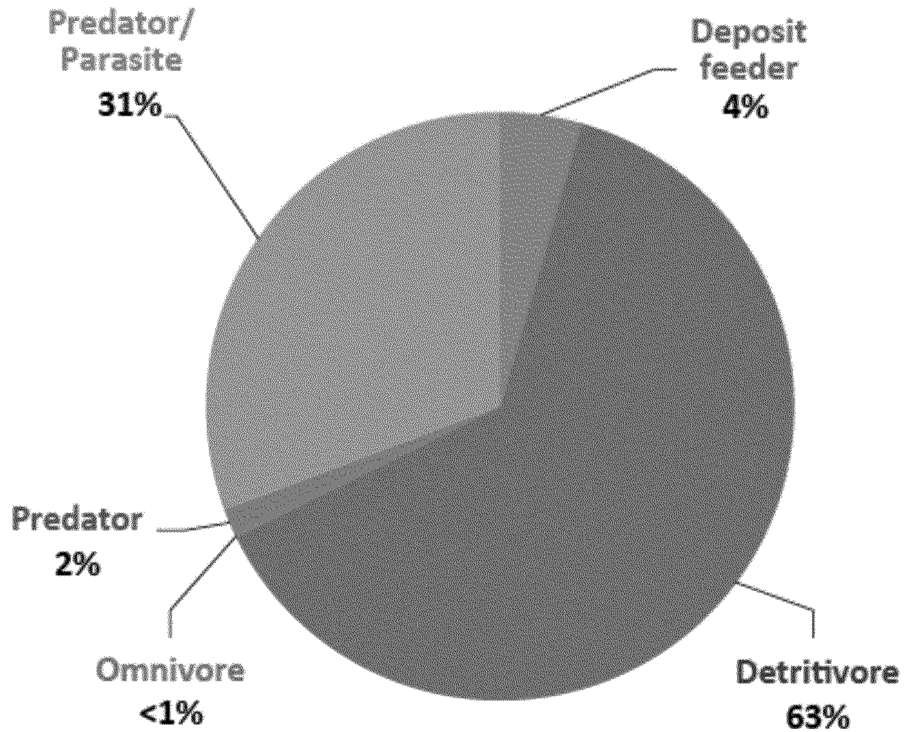


Freshwater Community

Freshwater LPRSA abundance (per m²)

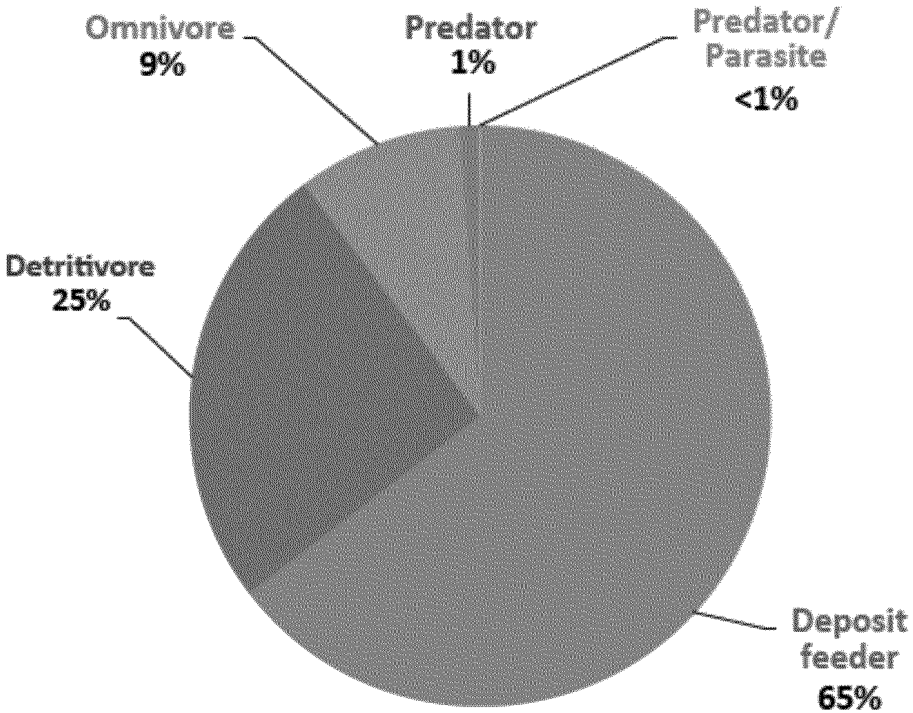


Freshwater LPRSA biomass

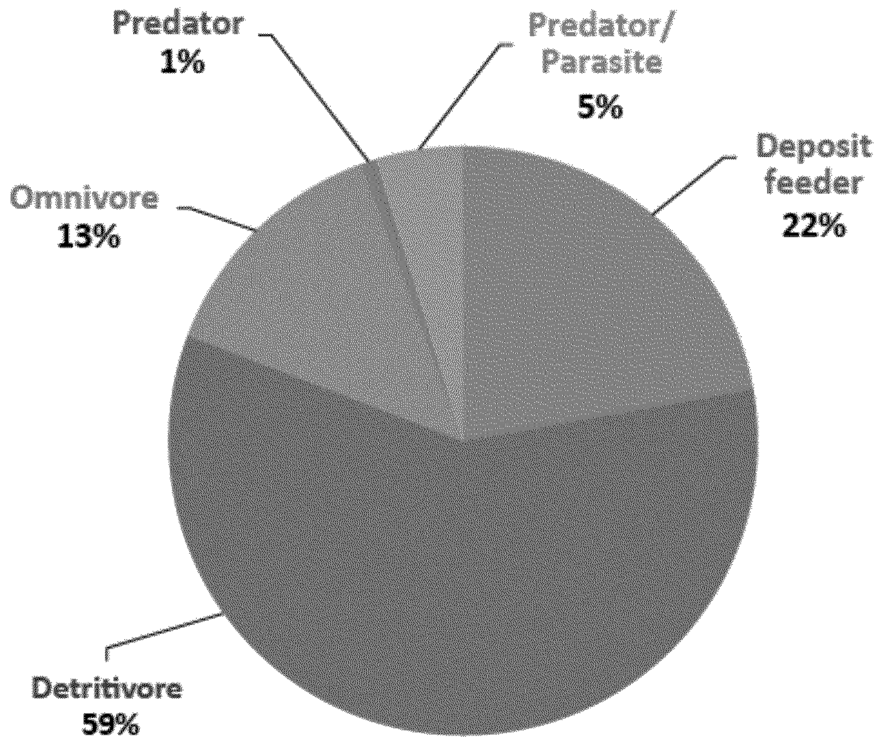


Estuarine Community

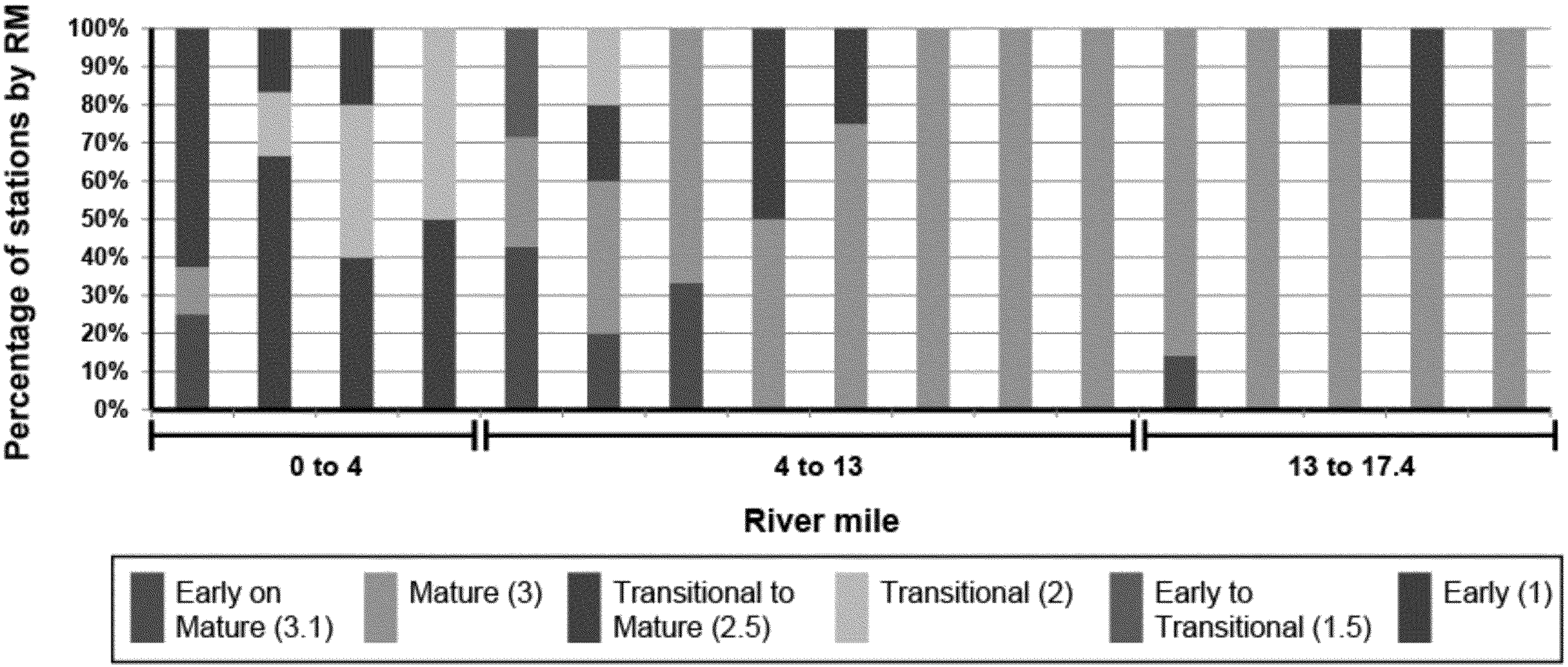
Estuarine LPRSA abundance (per m²)



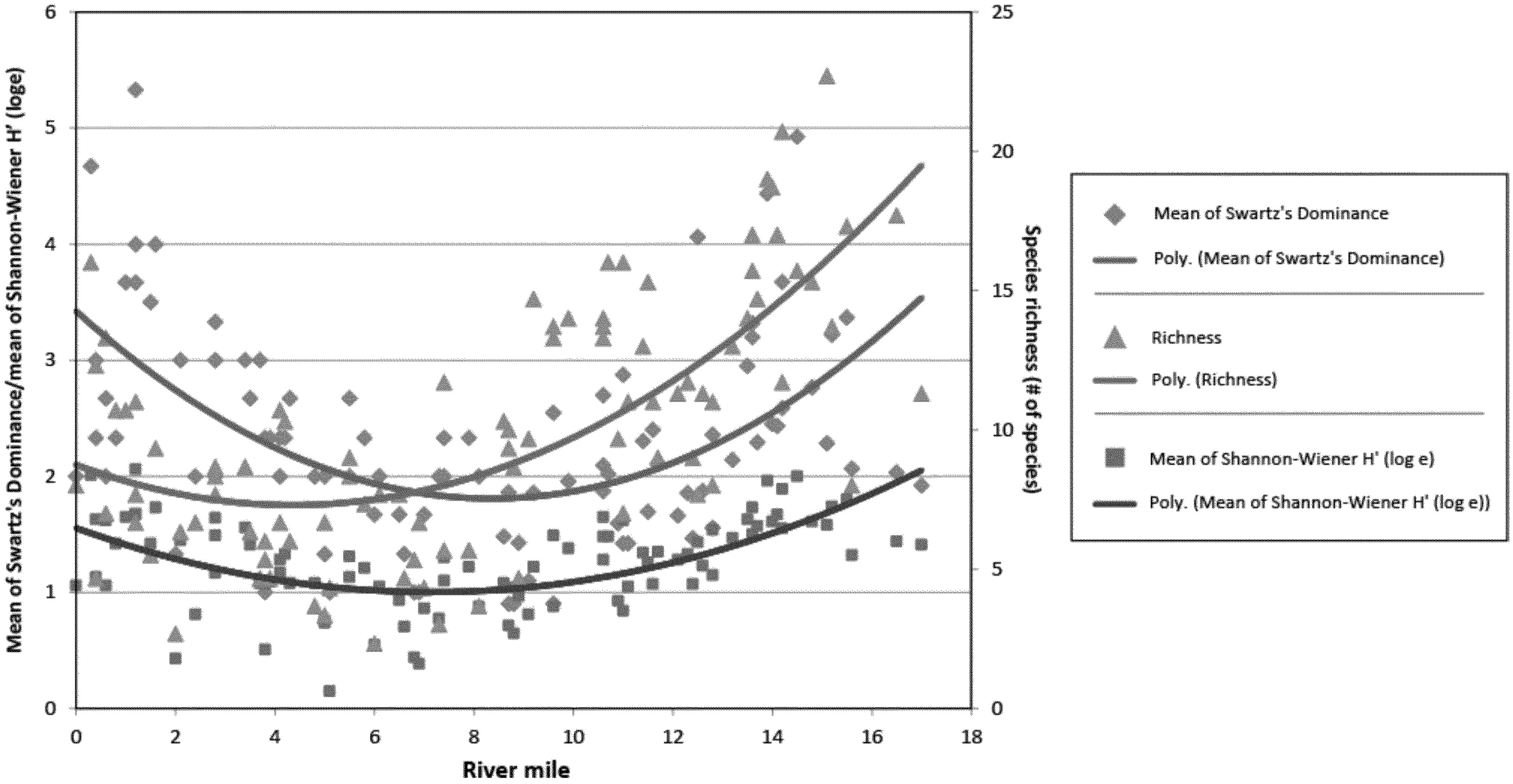
Estuarine LPRSA biomass



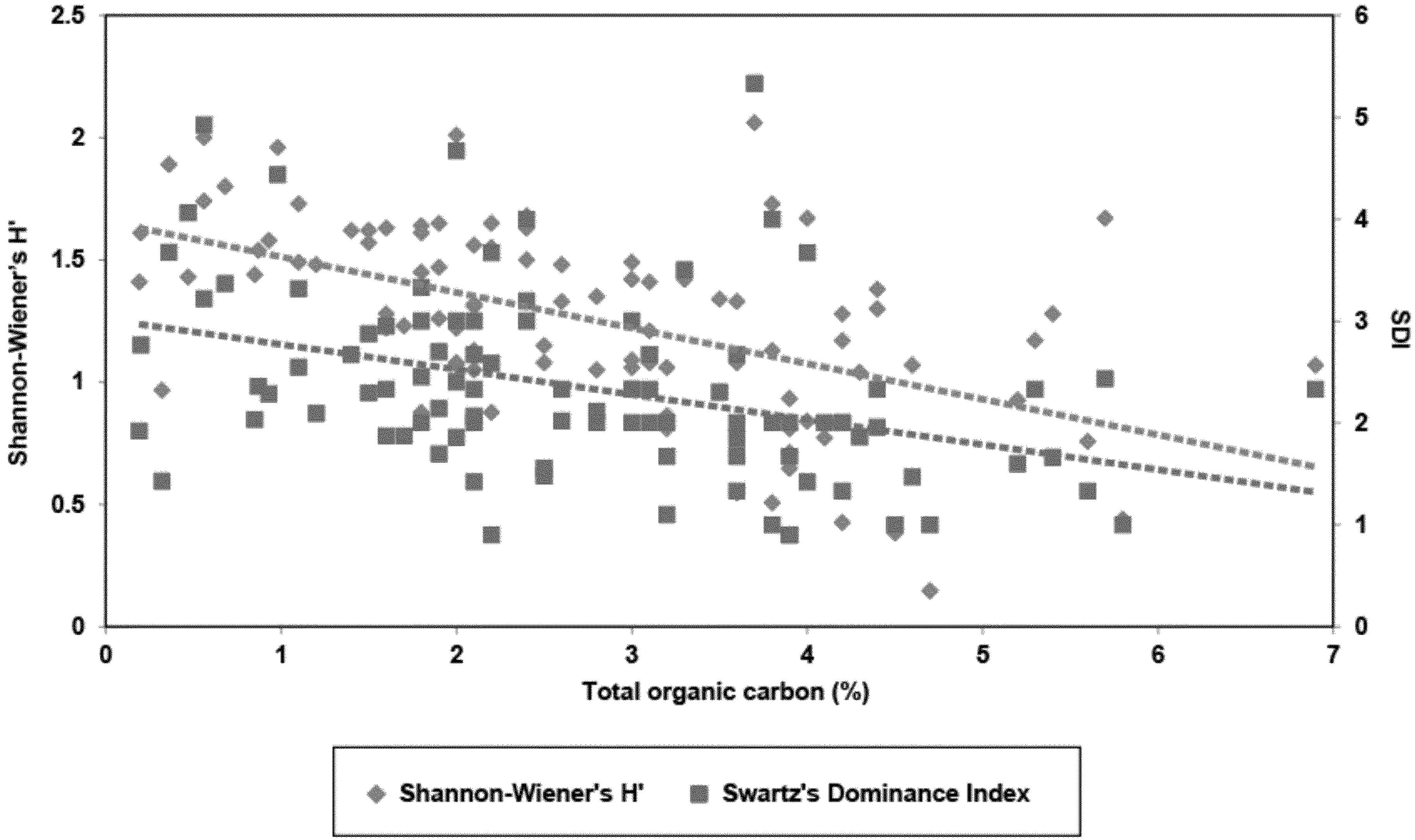
Benthic Community Successional Stage



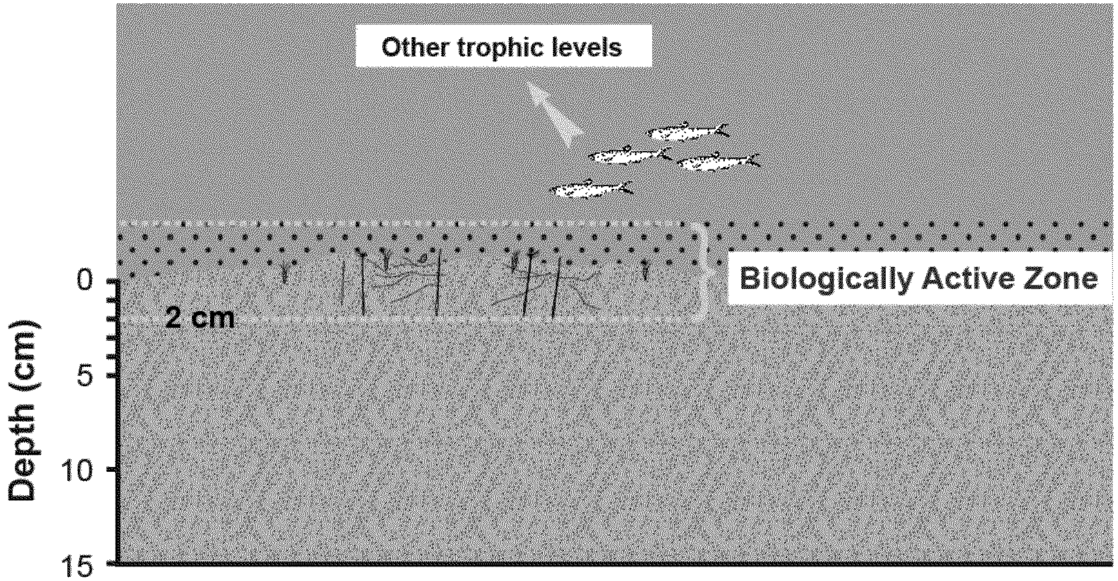
Benthic Metrics by River Mile



Benthic Diversity and Organic Enrichment



Benthic CSM for Lower Passaic River



- Organisms feed in sediment surface and floc layer – even head-down feeders are using only the top 1-2 cm of the sediment
- Redox Potential Depth – from Germano & Associates (2005) for the EPA/PAs
  - Brackish stations ranged from 0.1 to 4.0 cm - mean of 1.6 cm
  - Tidal stations were 0.4 to 5.0 cm with a mean of 1.9 cm

Summary

- LPRSA has a mature benthic community that is consistent with expectations for a salt wedge estuary, predominately detritivores and shallow deposit feeders
- Benthic community structure governed by non-chemical factors
- The exposure pathway between sediment and fish (and wildlife that ingest sediment and/or benthic invertebrates) is complete
- Benthic organisms' chemical exposures occur predominately in the upper 1-2 cm of bedded sediment and overlying floc
- Evaluating recovery in the top 2 cm and using risk estimates is supported by the site-specific empirical data